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TRAUMA SURGERY (J. DIAZ, SECTION EDITOR)

Current Management of Splenic Injuries: Who Needs a Splenectomy?

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Abstract
Purpose of Review This is a review of the current indications for splenectomy for trauma.
Recent Findings As the role of interventional radiology and the acceptance of non-operative strategies gain wider acceptance, the role of splenectomy is decreasing. There continues to be questions on how far the role of non-operative management can be pushed and at what cost. Alternatively, that risk must be weighed against the long and short term consequences of a splenectomy.
Summary Emergent surgical exploration of the abdomen is indicated for hemodynamically unstable trauma patients and patients with peritonitis from an associated injury. All other patients can be considered for non-operative management with various adjuncts to maximize effectiveness.

Keywords Splenectomy · Splenic trauma · Splenic embolization · Complication of splenic surgery

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Introduction

For many years, bleeding to death from a splenic injury has been considered a never event at many institutions. In the absence of a complication, splenectomy is curative for splenic trauma. Those two facts have driven the management of splenic trauma for decades. While the non-operative management of splenic trauma has become more prevalent, the above mentioned never event guides how far that path can go. If we decided to save all spleens, we would have to accept that some patients would fail and proceed to bleed to death without intervention. Trauma surgery as profession has been unwilling to accept that leading to a continued role for splenectomy.

The benefits of splenic conservation are well recognized and include the elimination of the risk of post-splenectomy infectious complications as well as avoiding potentially unnecessary surgery and the complications of a laparotomy. Non-operative management (NOM) is successful in more than 96% of the patients it is attempted on in most of the recent literature. Through the aid of protocols and liberal use of interventional radiology, that number may be even higher. What is unknown is if that number could be pushed even higher if trauma centers would be willing to accept transient hypotension and ongoing transfusions to preserve spleens. In general, the development of either of those triggers has signaled the end of non-operative therapy. Surgeons of the past have favored splenectomy likely due to a under appreciation of the importance of the spleen. As more data emerge on the complications of the short- and long-term complications of splenic surgery, there has been a greater emphasis to preserve splenic function.

Even in the current environment of non-operative management, there is still a role for splenectomy. Surgical management is required in approximately 20–40% of patients sustaining splenic injury. This article will focus on the predictors and indications that still exist for surgical intervention.

Indication for Splenectomy

Any unstable patient who has a positive focused assessment with sonography in trauma (FAST exam) or diagnostic peritoneal aspiration/lavage (DPA/DPL), which may be due to an injured spleen, should undergo laparotomy to control life-threatening hemorrhage and evaluate for splenectomy. In any study examining blunt splenic injury, these patients who have an immediate indication for surgery are excluded from non-operative management of their injuries. These usually represent around 25% of all the patients with blunt splenic injury and can represent a mix of splenic laceration grades and associated injuries [1]. This indication is absolute.

While patients that fall in the category of transient responders can be considered for non-operative management (NOM), circumstances must be optimal for them to avoid splenectomy. Non-operative management requires adequate resources (i.e., availability of interventional radiology, blood products, post-embolization monitoring, a rapidly available surgeon, OR, and staffing to provide for potential operative intervention). In addition, NOM requires a surgeon who is willing to stay with the patient and shepherd them through the period until they become stable. It is key that the surgeon remain constantly aware of the patient's hemodynamic status throughout this process, as any deviation from the march toward stability must be addressed with immediate operative intervention. Withholding a curative therapy when available would be malpractice. If operating room time or surgeon availability is limited, the provider should weigh the relative risks and benefits of splenectomy versus transfer to a tertiary referral center that is able to support the potential for non-operative management. Splenectomy may be the best option for surgeons whose institutional resources cannot support NOM of splenic injury, depending on the patient's comorbidities.

As with virtually any abdominal pathology the presence of peritonitis would necessitate exploratory laparotomy. Fifteen to twenty percent of splenic injuries will have a concomitant injury [2, 3]. While attempting NOM, the practitioner should be keenly aware that the patient could have an associated injury. If a patient were to develop peritonitis while undergoing NOM, they should undergo laparotomy as indicated. While the possibility of splenic salvage is possible at the laparotomy for the other pathology, often the momentum is difficult to avoid splenectomy. Certainly, if the other pathology has led to physiologic derangement the most appropriate treatment would be to take the spleen out of the clinical picture.

Other traumatic injuries have also been cited as an indication for splenectomy. Patients with severe liver injury were thought to need splenectomy to avoid a complicated picture in the setting of hypotension. With today's imaging technology and the advancements in critical care, this is no longer true. We can address complex intra-abdominal injuries and preserve spleens with low-grade injuries. Similarly, patients with severe head injury were thought to need splenectomy to avoid unnecessary hypotension in the setting of traumatic brain injury. With continuous monitoring and ICU protocols in place, the risk of prolonged hypotension and secondary injury to already injured brains is minimized, if not omitted. The need to remove a spleen secondary to concomitant brain injury is impractical and proven to be unnecessary in the literature [4].

The Role of Comorbidities

Comorbities can be viewed as either an operative indication or reason to press non-operative management. There is no doubt that a laparotomy incision can decrease pulmonary function and should be avoided, if possible, in a patient with already compromised pulmonary function. Conversely, chronically ill patients will have lower physiologic reserve and may not tolerate being pushed to the limits of NOM. Some patients need to be considered for potential splenectomy. Certain chronic illnesses can have a direct effect on the success rate of NOM. For example in cirrhotic patients NOM success is poor (8%), with a mortality of 55% following splenectomy in the failure group [5].

One must also consider the complications of splenic embolization in conjunction with the patient's comorbidities, when determining the best management strategy. Hsieh and authors showed that independent risk factors for contrast induced nephropathy (CIN) in patients undergoing splenic embolization included BMI > 30 kg/m^2, ISS ≥ 25, Hb < 10 g/dL. In addition, CIN and diabetes were found to be significant predictors of mortality in patients with blunt splenic injury. Patients with hepatic and renal dysfunction should be considered for splenectomy in situations where patients are borderline on operative indications.

Predictors of the Failure of Non-operative Management

Failure of non-operative management must be recognized promptly to provide expeditious management of ongoing, life-threatening hemorrhage. Therefore, patients managed non-operatively are felt to be best served by being under the care of a surgical team capable of rapid operative intervention. Often times this requires care at a trauma center. While non-operative management can be successfully performed at non-trauma centers, it requires the immediate availability of not only a surgeon but all the members of an operative team, as well as an available operating room. There is also convincing evidence that the success rate of non-operative management can be increased with interventional radiology which may not be universally available.

Several risk factors have emerged from the literature to identify at risk populations for failure. Many studies have shown various associations but the demographic variables that are most consistently associated with increased failure rate are age and injury severity. In a retrospective series ($n = 2243$), patients who failed non-operative management were more likely to be older than 55 years or to have an ISS higher than 25 [1].

The role that age plays in NOM of spleen is controversial. Most of the literature would support people over the age of 55 having a higher failure rate of NOM. Often the justification is that as we grow older the spleen capsule thins and becomes less elastic [6]. It is important to note that these patients are predicted to fail NOM which does not exclude them from trying it. While they are at greater risk of failure, one could argue that the older population stands to receive a greater benefit from NOM, considering the decreased physiologic reserve and the benefit from avoiding a large laparotomy incision. Furthermore, it is hard to disambiguate from the avalanche of retrospective data on the subject if older patients tend fail because of ongoing bleeding or if surgeons are more apt to operate on an older patient.

Secondly, the grade of the splenic injury predicts the overall rate of splenic preservation, as well as success of non-operative management. Frequency of immediate operation correlated with American Association for the Surgery of Trauma (AAST) grades of splenic injury: I (23.9%), II (22.4%), III (38.1%), IV (73.7%), and V (94.9%) ($p < 0.05$). Similarly, of patients initially managed non-operatively, the failure rate increased significantly by AAST grade of splenic injury: I (4.8%), II (9.5%), III (19.6%), IV (33.3%), and V (75.0%) ($p < 0.05$) [7••]. While higher grades of splenic injury resulted in a higher rate of failure, no splenic grade necessitates splenectomy in the face of hemodynamic stability. For example, it is important to note that even Grade 5 injures have a greater than 25% success rate for NOM. While this takes diligent observation, it would be remarkable that injury graded as avulsion of the organ can be treated non-operatively at all. Most studies would conclude that splenic injuries have an unpredictable progress and proving there is not always an obvious correlation between the anatomical lesion severity and clinical outcome [8].

In addition to these radiographic grading systems, radiographic characteristics not accounted for by AAST grading also may play a significant role in the success of NOM. A contrast blush (CB), for example, remains a high risk finding for non-operative management and is associated with an increased failure rate of NOM in adults with blunt splenic injury. [9] A contrast blush is described as a hyperdense, well delineated, intraparenchymal contrast collection [10]. This likely represents extravasation of contrast outside of the normal vascular distribution, concerning for an injury involving adjacent vasculature. In retrospective studies, among patients that failed NOM, 67% had a contrast blush on their index CT. Based on these findings, the authors concluded that the presence of a contrast blush was associated with 24-fold increased risk for failure of non-operative management.

While some trauma surgeons will tell you that any patient that needs a transfusion to maintain hemodynamic stability should be taken for a splenectomy, others are willing to accept some amount of transfusion to either maintain non-operative management. This is usually done to either get a patient safely to interventional radiology or in order to allow time for the spleen to become hemostatic itself. The number of units transfused is no longer an absolute contraindication to NOM [11]. The literature would say that less than 4 units would still predict successful NOM [12•, 13]. Even 2 units of transfused blood during the first 48 h (in order to maintain a HGB level above 8 g/dl) is compatible with a successful NOM [14]. While these thresholds tell us what is likely safe, it is unknown if higher thresholds are safe or would result in additional splenic preservation. Each surgeon must determine what they are comfortable with and set that threshold prospectively. It could be easy to justify higher transfusion thresholds on an individual basis while caring for a patient; however, this rolling number could lead to a situation which puts the patient's health at risk unnecessarily.

It is important to note that a large percentage of these patients (> 50% in some series) will fail later than 5 days from injury. Whether this represents delayed capsule rupture, pseudoaneurysm rupture, or ongoing bleeding is unknown. The combination of increased use of NOM and decreasing hospital stays may increase the opportunity for outpatient rupture. Among patients treated with non-operative management initially, 1.4% ultimately required splenectomy and the median time to splenectomy was 8 days [15].

Adjunct to Maximize Outcomes of Non-operative Management

There are convincing data that interventional radiology can increase the rate of successful non-operative management in higher grade splenic injuries. Davis and colleagues examined the effect of angiography and embolization on psuedoaneurysms. Using aggressive identification and prophylactic angiography and embolization, they increased their success rate of non-operative management to 94% (from 87%), essentially more than halving their failure rate [16••]. Among those patients with pseudoaneurysm, successful prophylactic embolization was avoided a splenectomy 100% of the time, while technical failure of embolization necessitated splenectomy. These data are often cited as evidence that these pseudoaneurysms progress and are responsible for the late ruptures described in the literature. On the converse side a Western Trauma multi-institutional study showed that in 200 patients with a traumatic splenic vascular abnormality did not show that rate of late failure was affected by performing an angiogram [17].

Miller and colleagues showed that a protocol that required all grade 3 or higher splenic injuries that underwent non-operative therapy to receive angiogram would increase the success rate of NOM from 85 to 95%. Patients had combination of selective and proximal embolization in the protocol [18•]. There is additional evidence that proximal embolization is more effective than distal embolization and will decrease NOM failure rates by 20% [19].

Alternatives to Splenectomy: Splenic Salvage

The decision to perform splenectomy versus splenic salvage (i.e., splenorrhaphy, partial splenectomy) is made based upon the grade of injury, presence of associated injuries, patient's overall condition, and experience of the surgeon. The small future risk of overwhelming post-splenectomy sepsis needs to be balanced against the more significant risk of recurrent hemorrhage.

Splenic salvage was extensively practiced in the 1980s and up to the mid-1990s; however, splenectomy is consistently more commonly used, likely because more lower-grade injuries in hemodynamically stable patients are managed non-operatively. When considering splenic salvage, the surgeon must determine whether the patient can tolerate rebleeding and reoperation for the small, but real, risk of recurrent hemorrhage [20–22]. Splenectomy is often a more appropriate choice for patients with multiple injuries or comorbidities who may not tolerate a significant or recurrent episode of hypotension or a second surgical procedure.

One area where there may still be a role for splenic salvage would be when operating on the patient for another indication. Splenectomy is also more appropriate for patients requiring urgent surgical management of other significant injuries that preclude taking the extra time needed for splenic salvage. In the setting of damage control, delayed splenic salvage can be considered (within 24–48 h) for low-grade splenic injuries, provided that the bleeding is controlled with packing. Splenectomy is the safest option, given that most patients who require damage-control surgery are on the brink of physiological collapse; are hypothermic, acidotic, coagulopathic; and will likely only poorly tolerate recurrent hemorrhage.

There are a number of splenic salvage techniques published in journals and textbooks, though no formal comparisons have been made. The selection of specific techniques, materials, and sutures are dependent on individual surgeon experience and preference. Observational management, with or without splenic embolization, has made splenic salvage an infrequent procedure in surgical practice. In the current era patients who fail non-operative management will require a splenectomy.

Splenorrhaphy Splenorrhaphy refers to the suture repair of the spleen with or without splenic wrapping and is generally supplemented by electrocautery techniques for control of parenchymal hemorrhage.

Intraparenchymal bleeding is controlled first, followed by reapproximation of the splenic tissue and capsule when possible. Hemostasis can be achieved with topical hemostatic agents, electrocautery, or argon beam coagulation [23, 24]. The choice depends upon availability and surgeon preference. A mass closure technique using absorbable sutures, with or without supporting pledgets, is used to reapproximate the splenic tissue [25, 26]. When reapproximation of the tissue is not feasible, due to tissue friability, a tongue of omentum can be laid into the open defect and sutured into place.

The spleen can be wrapped in an absorbable hemostatic mesh to facilitate tissue approximation and effect tamponade. The use of mesh does not appear to be associated with increased infection rates, even in patients who underwent mesh splenorrhaphy and concomitant bowel repair [27]. Splenic wrapping, however, can be time consuming, particularly in inexperienced hands, and has the potential to cause splenic ischemia if the wrapping is too tight at the hilum, or may allow recurrent hemorrhage if the wrap is too loose. Significant residual bleeding in spite of repair indicates the need for splenectomy.

Partial splenectomy Partial splenectomy is a form of splenic salvage and refers to the removal of a portion of the spleen based upon its segmental blood supply. Partial splenectomy leaves behind a raw surface, which may have an unacceptably high risk of recurrent hemorrhage, especially in patients with coagulopathy and those at risk for high venous pressures (e.g., portal vein injury, pre-existing cirrhosis). Accordingly, partial splenectomy is an infrequently selected technique to manage splenic injury.

The hilar vessels supplying the irreparably damaged portion of spleen are ligated and divided. After the surface of the spleen demarcates into viable and nonviable portions, the nonviable portion is removed using a scalpel or electrocautery. The cut edge of the remaining spleen is managed with the splenorrhaphy techniques discussed above.

Operative approach Open exploration remains the standard of care for surgical intervention. While the laparoscopic approach has been described in case reports and small case series [28–30], a laparoscopic approach to manage splenic injury should only be considered in select cases. As an example, a low-grade injury found during diagnostic laparoscopy for penetrating trauma with minimal-to-no hemorrhage in a hemodynamically stable patient may be amenable to laparoscopic repair or, if needed, laparoscopic splenectomy.

The laparoscopic approach is hampered by inadequate visualization due to ongoing hemorrhage and potential hypotension (i.e., decreased venous return from pneumoperitoneum). Due to the general success of non-operative management strategies, surgical intervention is more typically performed in patients who are hemodynamically unstable. Under these circumstances, laparoscopic exploration is contraindicated due to the potential for further hemodynamic compromise.

Surgical outcomes and complications Morbidity and mortality in multitrauma patients are highly dependent upon the nature and severity of other injuries and medical comorbidities. The mortality rate for patients undergoing surgery for isolated splenic injury is also dependent on the grade of injury, as well as the presence or absence of shock. Mortality can be as high as 22% for grade V injury [31, 32].

Patients undergoing splenic salvage or splenectomy are at risk for the commonly reported complications of patients undergoing other abdominal procedures (e.g., surgical site infection, ileus, urinary tract infection). Pulmonary complications are the most common complications following splenic surgery after injury, with atelectasis found in 38%, pneumonia in 9%, and pleural effusion in 6% of patients in one retrospective study [33].

There has also been a recent study looking at the association between patients with concomitant splenectomies and long bone fractures. Animal models have shown that splenectomy may delay fracture healing time. This association has not, yet, been studied extensively in humans.

Postoperative bleeding Common sources of bleeding following splenectomy include the raw edges of the divided splenic attachments and short gastric or hilar vessel remnants. Bleeding that requires reoperation after isolated splenectomy is rare but has been reported to occur in 1.6% of patients in one series and may involve hemorrhage from surrounding structures (e.g., pancreatic tail) [34].

Gastric perforation Gastric perforation is uncommon (case reports only) but can result from necrosis of the gastric wall from the effects of the initial trauma, or ligation of the short gastric vessels where gastric wall tissue is incorporated into the suture ligature. Care must be taken to avoid placing the ties on the gastric wall.

Vascular thrombosis Thrombosis occurs in approximately 5% of patients following splenectomy [35, 36]. Thrombosis of any vein can occur, but the portal, mesenteric, and splenic veins appear to be affected more often [37]. Thrombocytosis may increase the risk for venous or arterial thrombosis following splenectomy, though the relationship between thrombocytosis and thrombosis remains unclear. The relative contributions of immobility, chromogenic fluid administration, other injuries, repeat operation, recurrent hypotension, and other factors may contribute more to thrombotic complications than thrombocytosis.

Pancreatic fistula Pancreatic fistula develops in approximately 1.5% of patients following splenectomy, due to injury of the tail of the pancreas, either from the initial trauma or due to splenic hilar dissection [33].

Any patient who develops left upper quadrant pain, fever, and leukocytosis after splenectomy should be imaged with ultrasound or computed tomography scan to identify any left upper quadrant fluid collections. The diagnosis of pancreatic fistula can be made by guided percutaneous fluid sampling, demonstrating amylase-rich fluid indicative of a pancreatic leak. Cultures of the fluid should also be sent to rule out an abscess, which is more common than a pancreatic leak.

Perioperative infection Following splenectomy, the patient is at a small but increased risk for postoperative infection [38, 39]. Splenic preservation in patients with blunt splenic injury by operative or non-operative management has been reported to lead to lower early infection rates (in adults) compared with splenectomy. As an example, one prospective study reported adult patients managed with observation, splenic repair, and splenectomy had postoperative infection rates of 5, 15, and 49%, respectively [38]. It is unclear whether the determining factor was the preservation of splenic tissue, or a reflection of injury severity allowing observation or requiring splenectomy. Pneumonia was the most common postoperative infection in all three groups, but not all infections were due to encapsulated organisms.

Intra-abdominal abscess complicates splenectomy in 3 to 13% of patients and is associated with concomitant intestinal tract injuries and the presence of splenic bed drains [40].

Post-splenectomy sepsis Post-splenectomy sepsis is a fulminant and rapidly fatal illness due to encapsulated pathogens [38, 39]]. The incidence of post-splenectomy sepsis associated with splenic injury appears to be lower than that for splenectomy performed for other indications. Autotransplantation of splenic tissue at the time of the injury (i.e., splenosis) may provide a critical mass of splenic tissue to confer some degree of splenic immunocompetence to the patient, although this is not reliably established [41]]. An alternate explanation is that splenectomy for trauma is more commonly performed in otherwise healthier (notwithstanding their traumatic injuries) individuals who have fewer medical comorbidities as compared with those undergoing splenectomy for other reasons.

Risk for malignancy A few studies have suggested that there is possibly an increased risk for malignancy following splenectomy (traumatic or non-traumatic), but in others, the association with malignancy following traumatic splenectomy has not been found [42–44]. In contrast a large population-based cohort study (n = 2295) found that both non-traumatic and traumatic splenectomy had a significantly higher risk for overall cancer development [45]. Traumatic splenectomy had a significantly increased risk for malignancy compared with controls (hazard ratio 1.28, 95% CI 1.06–1.60), but the identified risk was slightly lower than that of patients undergoing splenectomy for non-traumatic reasons. In subgroup analysis, among those with traumatic splenectomy, the increased risk compared with controls was significant among men, those younger than 45, and those with comorbidities. While this is not often used as a reason for splenic preservation it is interesting to note that the hazard ratio in the traumatic population is on par with the hazard ratio for increased incidence of head and neck cancer associated with CT of the neck which has lead to significant concern nationally.

Conclusions

The only absolute indication for splenectomy is hemodynamic instability. Emergent surgical exploration of the abdomen is indicated for hemodynamically unstable trauma patients who have a positive focused assessment with sonography in trauma (FAST) exam or diagnostic peritoneal aspiration/lavage (DPA/DPL) to control life-threatening hemorrhage, which may be due to an injured spleen. In these patients splenectomy is almost always the operation of choice.

Indications for surgical exploration in the hemodynamically stable trauma patient with splenic injury include a contraindication to non-operative management, evidence of another intra-abdominal injury requiring surgery, and failure of non-operative management. Failure of non-operative management is defined as development of hemodynamic instability or peritonitis. Also a persistent transfusion requirement could be an indication guided by a predetermined operative trigger most commonly > = tp 4 unit of packed red blood cells.

Interestingly the label of conservative management has changed practice in recent literature. Surgeons in general shun the label of being "conservative" as they strive to push the envelope in the advancement of the field. Conservative management used to refer to non-operative management with surgery being associated with an aggressive approach. In the current era of heightened concern of the long-term effects of being asplenic and the risks of complications those providers pushing the edge of non-operative management have become the perceived risk takers. The splenectomy has become the conservative approach and while still indicated continues to have a diminishing role in current practice.

Compliance with Ethical Guidelines

Conflict of interest Nathan Teague Mowery, Charles Caleb Butts, and Erika Borgerding Call declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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